

## 2.4.8. Range and Bearing Resolution

### 2.4.8.1. Purpose

The purpose of this test is to measure the range and bearing resolution of the radar and to assess the effects that the radar resolution has upon the utility of the radar for discriminating or "breaking out" targets closely spaced in range and bearing.

### 2.4.8.2. General

Theoretical range and azimuth resolution are discussed in the radar theory section. The radar display can have a pronounced affect upon resolution. The air-to-ground radar resolution is important because it allows the operator to break out individual targets in the target area, increasing the precision with which weapons can be delivered. As an example, high resolution may allow the operator to pick out individual airplanes on a ramp next to a hangar. This allows a direct attack of the airplanes rather than the hangar in the hope that the airplanes will be housed in the hangar.

Accurate range and bearing resolution tests are difficult to perform and require a significant amount of flight time to complete. For this reason, a qualitative evaluation will be performed first and if problems are noted with resolution, then the actual measurements will be obtained. The requirements for the range and bearing resolution are usually outlined in the detailed radar specification; however, if a specification is not available, an analysis of the intended mission and targets will allow the evaluator to choose a reasonable requirement. Once these are known, mission relatable targets should be chosen that are near these limits. Normally, a look at the layout of the evaluator's own airfield will provide a number of choices for the test. Isolated buildings with the appropriate separation make good targets. Isolation makes these buildings easy to find on radar since they are by themselves and are easily detectable, due to their size.

For range resolution, the targets should be aligned with the radar line of sight. The range to the targets is unimportant as long as they are detectable and are not so far away that the grazing angle causes the front target to mask the back target. Usually a range of 10 nm with a medium test altitude works well. For

the azimuth resolution test, targets should be chosen that are separated by enough distance to allow the radar to break the targets out at around 10 nm given the minimum azimuth resolution requirement as described above. The desired target separation can be determined by solving a right triangle using the desired angular resolution as one internal angle and 10 nm as one of the adjacent sides. Again, the targets should be isolated to make them easy to find in the clutter and large enough to make them easily detectable beyond 10 nm.

Sometimes targets can be found that allow both tests to be flown in a single event. This requires that both sets of targets be roughly perpendicular in orientation. It is critical to ensure that the flight path is aligned perpendicular to the azimuth resolution targets. This is important since most radars are better at resolving targets in range than in azimuth. If the alignment is incorrect, the azimuth targets may break out in range and contaminate the azimuth resolution data point. The range resolution target alignment is conversely not as sensitive to the flight path. For radars with modes of differing resolution, the azimuth test can be performed in a single run by checking the best resolution mode first and then the rest as the range is closed.

As mentioned earlier, if the range and the azimuth targets are resolvable at the required range, then the range and azimuth resolution can be considered to be satisfactory and the test is complete. If not, then the radar will have to be flown against a radar resolution array to measure the actual range and azimuth resolution limits.

The radar resolution array is a set of surveyed radar reflectors arranged in a "T" shape. The top of the T provides the azimuth test and the base provides the range test. Corner reflectors are used for the targets and they generally have an optimum beam width of around 15°. The reflectors are optimized at some angle above the horizon. Since the array is aligned along an angle above the horizon, a constant flight path angle must be flown to the array. The best way to perform this maneuver is to choose a start range, and knowing the desired flight path angle, derive a start altitude. A reasonable descent speed should then be chosen and from that, a descent rate to arrive over the top of the target at a chosen minimum

altitude. For example, using an angle of 10° above the horizon for the array alignment, a sea level array, and a 35 nm start range, the initial altitude would be 37,000 feet MSL. Using a 300 KIAS descent (disregard altitude/temperature/ position errors etc.) requires roughly a 7 minute trip to the target. A 200 feet AGL minimum altitude and a sea level target requires a 36,800 / 7 feet/minute rate of descent to stay within the array alignment.

The resolution tests are difficult to fly because they require a steep descent at the correct flight path angle to stay within the vertical angular limits of the array while at the same time aligning the airplane along the centerline of the array and constantly monitoring the radar display for breakout. The horizontal angular width is particularly a problem for testing DBS modes since the DBS notch prevents the airplane from flying directly at the target. A zigzag pattern is required with quick turns to prevent missing the data point as the target passes through the nose.

For the range test, the maximum number of targets broken out of the base of the T at any time during the run is recorded. Theoretically, range will not affect the number; however, arrays sometimes are made of more than one size target and the smaller targets will not break out until the test airplane is close to the array. The targets are arranged with differing separations, usually the widest spaced target at the base and the closer spacing towards the top of the array.

#### 2.4.8.3. Instrumentation

Data cards, a radar resolution array and an optional voice recorder are required for this test.

#### 2.4.8.4. Data Required

For the targets chosen at the home field, record whether the targets aligned along the flight path can be broken out and for the targets aligned perpendicular to the flight path, record the range at which they can be broken out. While using the radar resolution array, record the total number of targets found during the run aligned along the base of the T and the range and total number of targets broken out as each new target becomes resolvable at the top of the T. During mission relatable ingresses and attacks, record the effects that the radar resolution

has upon the utility of the radar for finding individual targets that are closely spaced in range and/or azimuth.

#### 2.4.8.5. Procedure

Before the flight, determine the requirements of the radar for range and bearing resolution. Obtain a diagram of the home airfield or some other field in the vicinity of the test area. Find two targets, such as buildings, that are spaced near the range resolution requirement. Using the required angular resolution limit, find two other targets that are spaced so that they should break out at 10 nm of range. If possible, choose the two sets of targets so that they can be flown simultaneously, that is, aligned perpendicularly. Climb to a medium altitude and fly inbound along a ground track aligned with the range targets. Continue inbound until the targets break out or until overflight. Record if breakout occurs. Starting at 15 nm, fly inbound along a heading perpendicular to the orientation of the azimuth targets. Continue inbound to 10 nm, noting if breakout occurs. If two sets of targets were found that were roughly perpendicular so that the tests could be flown in one run, care should be taken to be as close to perpendicular to the alignment of the azimuth resolution targets as possible. If the range targets break out at any time and the azimuth resolution targets break out by 10 nm, then flying against the resolution array is not required.

If the resolution array is required, use the technique outlined earlier to determine the initial altitude, airspeed and rate of descent to the array. For a non-DBS mode without a notch, start at the initial point and head directly to the array aligned along the base of the T. Care should be taken to remain within the beam width of the array corner reflectors. Reduce the rate of descent early enough to allow a comfortable arrival at the minimum altitude at overflight of the array. Record the maximum number of range targets broken out, and the range and number of targets broken out each time a new target becomes resolvable. For a DBS mode, a direct route along the center of the beam width to the array will not be possible since the target cannot be in the DBS notch. A zigzag course is required, turning when the magnetic bearing to the target approaches the centerline plus or minus the beam width. Quick turns are required so that it will be unlikely

that a breakout will occur during the time of the turn. Record the same data as for the real beam test. During mission relatable ingresses and attacks, note the effects that the range and bearing resolution has upon the ability of the radar to discriminate targets spaced closely in range and bearing.

#### 2.4.8.6. Data Analysis and Presentation

If the radar was able to break out the mission relatable range target at any range and the azimuth targets by 10 nm and no problems were noted during the mission relatable ingresses and attacks, then the range and azimuth resolution is satisfactory. If the radar was not able to break out the targets, relate the poor resolution to the ability of the radar to break out mission relatable targets and the requirement to visually designate individual targets. Count off the resolution array range targets from widest spacing to closest until one minus the total number seen are accounted for. The range resolution will be at least the spacing of the last target accounted for. For example, using data card 31, if 4 targets are seen, the resolution will be at least 100 feet. For the azimuth test, using the range to the targets and the range between them, a right triangle can be solved for the angular resolution at each target breakout. Again, using the array depicted on data card 31, if 3 targets are broken out at 10 nm, the angular resolution is:

$$\text{Angular Resolution} = \frac{(300 \text{ feet})}{(10 \text{ nm}) \left( 6076 \frac{\text{feet}}{\text{nm}} \right)} \quad (21)$$

Use the data to support the qualitative evaluation. Relate any additional problems noted during the ingresses and attacks.

#### 2.4.8.7. Data Cards

Sample data cards are presented as card 31.

CARD NUMBER \_\_\_\_ TIME \_\_\_\_ PRIORITY L/M/H

## AIR-TO-GROUND RANGE AND BEARING RESOLUTION

[CLIMB TO \_\_\_\_ FEET MSL, SET \_\_\_\_ KIAS. FIND THE RANGE AND AZIMUTH TARGETS AND DESIGNATE THEM WITH THE CURSORS. SET UP TO FLY \_\_\_\_° MAGNETIC HEADING INBOUND TO THE TARGET STARTING AT 15 NM. RECORD IF THE RANGE TARGETS BREAK OUT AND IF THE AZIMUTH TARGETS BREAK OUT BY 10 NM. REPEAT FOR EACH MODE.]

MODE	RANGE TARGETS BREAK OUT (YES/NO)	AZIMUTH TARGETS BREAK OUT (YES/NO)

RANGE AND AZIMUTH RESOLUTION QUALITATIVE TARGETS:

{ADD A TARGET AREA DIAGRAM HERE TO AID IN TARGET AREA ORIENTATION.}

## AIR-TO-GROUND RANGE AND BEARING RESOLUTION

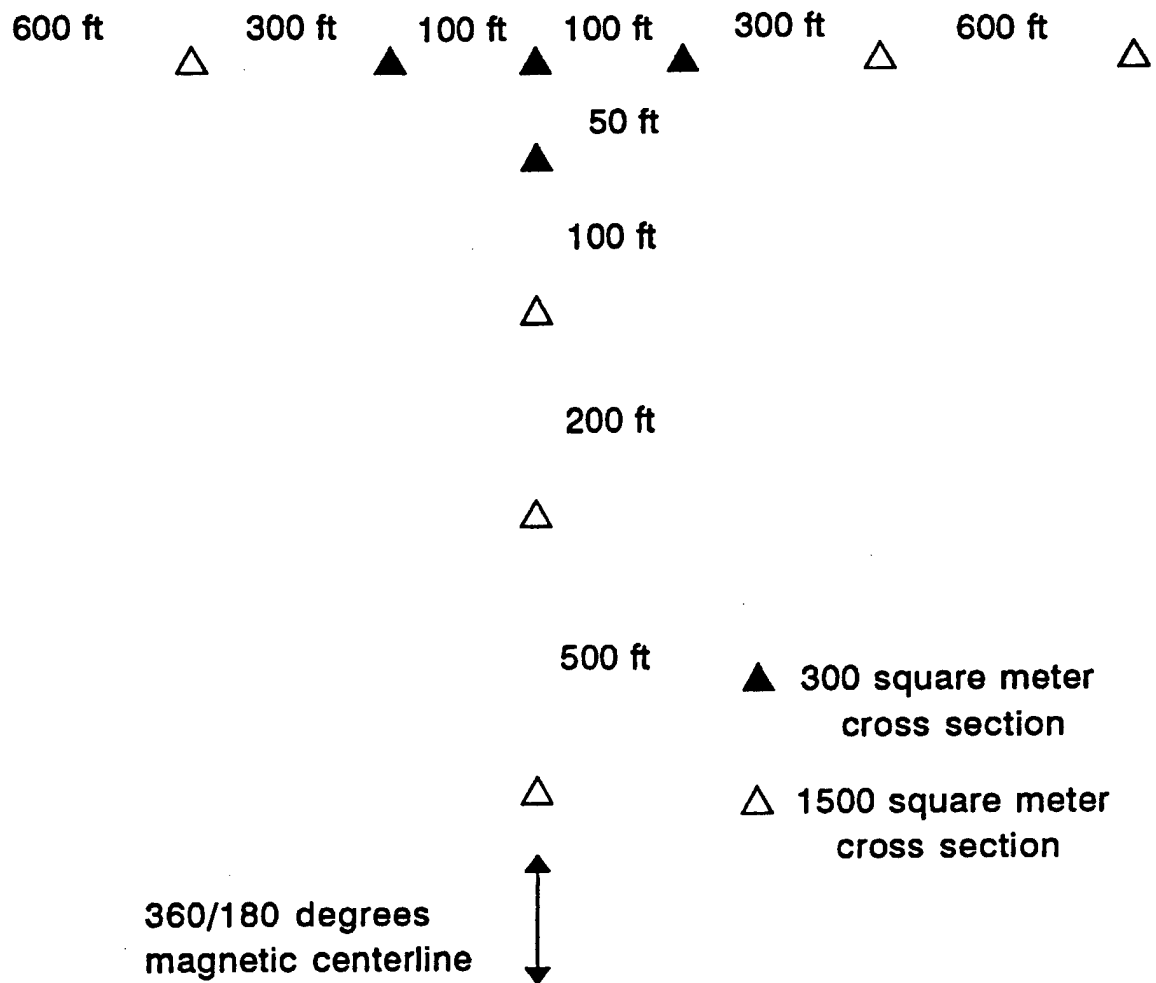
[CLIMB TO \_\_\_\_\_ FEET MSL AND SET \_\_\_\_ KIAS. PROCEED TO A POINT \_\_\_\_ NM AWAY FROM THE ARRAY ORIENTED ALONG THE \_\_\_\_ BEARING TO THE TARGET. ACQUIRE THE ARRAY ON RADAR AND DESIGNATE WITH THE CURSORS. STAY IN THE BEAM WIDTH OF THE ARRAY. USE A \_\_\_\_\_ FEET/MINUTE RATE OF DESCENT. REPEAT FOR EACH RADAR MODE.]

MODE	MAXIMUM NUMBER RANGE TARGETS	AZIMUTH TARGETS NUMBER/RANGE

[RECORD QUALITATIVE COMMENTS CONCERNING THE UTILITY OF THE RADAR TO BREAK OUT TARGETS CLOSE IN AZIMUTH AND RANGE.]

EFFECTS:

## RESOLUTION ARRAY DIAGRAM



## RADAR RESOLUTION ARRAY DIAGRAM

